

PLANT ITEM MATERIAL SELECTION DATA SHEET



UFP-VSL-00001A/B (PTF)

ISSUED BY
RPP-WTP PDC

Ultrafiltration Feed Preparation Vessel

- Design Temperature (°F)(max/min): 150/40
- Design Pressure (psig) (max/min): 15/-12
- Location: incell
- PJM Discharge Velocity (fps): 40
- Drive Cycle: 17 % (at 40 fps)

Offspring items --

UFP-VSL-00001A --

UFP-PJM-00001 - UFP-PJM-00004

UFP-PJM-00044, UFP-PJM-00053

UFP-PJM-00105 - UFP-PJM-00106

UFP-VSL-00001B --

UFP-PJM-00045 - UFP-PJM-00050

UFP-PJM-00101 - UFP-PJM-00102

Contents of this document are Dangerous Waste Permit affecting

Operating conditions are as stated on attached Process Corrosion Data Sheet

No maintenance will be performed on these vessels.

Operating Modes Considered:

- Normal operating conditions
- The vessel may be cleaned using 2 N HNO₃ with residual chlorides and fluorides at normal operating temperatures; the condition of high temperature and acid is not examined.

Materials Considered:

Material (UNS No.)	Relative Cost	Acceptable Material	Unacceptable Material
Carbon Steel	0.23		X
304L (S30403)	1.00		X
316L (S31603)	1.18	X	
6% Mo (N08367/N08926)	7.64	X	
Alloy 22 (N06022)	11.4	X	
Ti-2 (R50400)	10.1		X

Recommended Material: 316 (max 0.030% C, dual certified)

Steam Ejector: high temperature components of steam ejector located inside vessel shall be UNS N06022

Recommended Corrosion Allowance: 0.040 inch (includes 0.024 inch corrosion allowance and 0.016 inch general erosion allowance; localized protection is required as discussed in section j)

Process & Operations Limitations:

- Develop flushing/rinsing procedure for acid and water.

Please note that source, special nuclear and byproduct materials, as defined in the Atomic Energy Act of 1954 (AEA), are regulated at the U.S. Department of Energy (DOE) facilities exclusively by DOE acting pursuant to its AEA authority. DOE asserts, that pursuant to the AEA, it has sole and exclusive responsibility and authority to regulate source, special nuclear, and byproduct materials at DOE-owned nuclear facilities. Information contained herein on radionuclides is provided for process description purposes only.



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PLANT ITEM MATERIAL SELECTION DATA SHEET

Corrosion Considerations:

Waste is maintained at 77°F by use of a chiller jacket. For Envelope C waste only, contents are heated to a temperature of 122°F necessary for Sr/TRU precipitation. A steam ejector is available to maintain the necessary reaction temperature. Chemical reagent additions are 19M NaOH followed by 1.0 M $\text{Sr}(\text{NO}_3)_2$ followed by 1M NaMnO_4 . It is anticipated periodic acid cleaning will be necessary.

a General Corrosion

Hamner (1981) lists a corrosion rate for 304 (and 304L) in NaOH of less than 20 mpy (500 $\mu\text{m}/\text{y}$) at 77°F and over 20 mpy at 122°F. He shows 316 (and 316L) has a rate of less than 2 mpy up to 122°F and 50% NaOH. Dillon (2000) and Sedriks (1996) both state that the 300 series stainless steels are acceptable in up to 50% NaOH at temperatures up to about 122°F or slightly above. Divine's work (1986) with simulated-radwaste evaporators, six months at 140°F, showed 304L was slightly more resistant to corrosion (<0.2 mpy) than was 316L (<0.6 mpy); Ni 200, pure nickel, was much less resistant (≈ 7 mpy) probably due to the complexants. Zapp (1998) notes that the Savannah River evaporator vessels, operating at about 300°F, are made of 304L and have suffered no failures in about 30 years. The 304L heat transfer surfaces have failed, however, after about 10 years. Danielson & Pitman (2000), based on short term studies, suggest a corrosion rate of about 0.5 mpy for 316L in simulated waste at boiling, >212°F. Davis (1994) states the corrosion rate for 304L in pure NaOH will be less than about 1 mpy up to about 212°F though Sedriks states the corrosion rate data beyond about 122°F are low due to the presence of oxidizing species.

Ohl & Carlos (1994) found in their review of the 242-A Evaporator, in waste similar to that expected in WTP, that the corrosion of 304L after about two years of operation at 140°F was less than the accepted variability of the original plate. Because of uncertainties in the starting thickness of the metal, a review of the raw data was inconclusive.

There is a concern about excessive corrosion rates during acid cleaning in the presence of the expected levels of fluoride. Acid wash should only be performed at normal operating temperatures in order to reduce the extent of attack by chloride (pitting and crevice corrosion) and general corrosion due to fluoride.

Conclusion:

At temperatures less than about 140°F, 304L or 316L are expected to be sufficiently resistant to the waste solution with a probable general corrosion rate of less than 1 mpy. Based on the Savannah River experience with Hanford-like waste at higher temperatures, either 304L or 316L is expected to be satisfactory to 300°F.

b Pitting Corrosion

Chloride is known to cause pitting in acid and neutral solutions. Dillon (2000) is of the opinion that in alkaline solutions, $\text{pH} > 12$, chlorides are likely to promote pitting only in tight crevices. Dillon and Koch (1995) are both of the opinion that fluoride will have little effect in an alkaline media.

Normally the vessel is to operate between 77°F and 122°F. At the normal temperature, based on the work of Zapp (1998) and others, 304L stainless steel would be acceptable in the proposed alkaline conditions. Under acidic or neutral pH conditions, 316L will be more resistant to pitting due to the chloride concentration.

If the vessel were filled with process water and left stagnant, there would be a tendency to pit. The time to initiate would depend on the source of the water, being shorter for filtered river water and longer for DIW. Therefore, controls on washing and rinsing are required.

The high temperature portions of the high pressure steam ejector that are located within the vessel shall be C-22.

Conclusion:

Localized corrosion, such as pitting, is common but can be mitigated by alloys with higher nickel and molybdenum contents. Based on the expected operating conditions and the possibility of acid washes inside the vessels, 316L is recommended.

c End Grain Corrosion

End grain corrosion only occurs in metal with exposed end grains and in highly oxidizing acid conditions. Acid cleaning should be performed only at normal operating temperature.

Conclusion:

Not applicable to this system.

d Stress Corrosion Cracking

The exact amount of chloride required to cause stress corrosion cracking is unknown. In part this is because the amount varies with temperature, metal sensitization, and the environment. It is also unknown because chloride tends to concentrate under heat transfer conditions, by evaporation, and electrochemically during a corrosion process. Hence, even as little as 10 ppm can lead to cracking under some conditions. Koch (1995) has noted that fluoride exacerbates chloride intergranular stress corrosion cracking. Generally, as seen in Sedriks (1996) and Davis (1987), stress corrosion cracking does not usually occur below about 140°F. With the low operating temperature and alkaline conditions, 304L and 316L are expected to be satisfactory in regards to resistance to chloride cracking. Davis (1987) suggests caustic cracking is a concern above about 212°F. However, Zapp's work (1998) implies that neither 304L nor 316L will crack in waste.

Conclusion:

Because of the normal operating environment as well as that which can occur during off normal conditions, and possibility of acid washing, 304L is the minimum alloy recommended and 316L may be marginally better.

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e Crevice Corrosion

The high solids loading may make deposits more common and, consequently, the vessel more susceptible to crevice formation. See Pitting.

Conclusion:

Lower temperatures and higher pH mitigate the formation of crevice corrosion. See also Pitting.

f Corrosion at Welds

Corrosion at welds is not considered a problem in the proposed environment.

Conclusion:

Weld corrosion is not considered a problem for this system.

g Microbiologically Induced Corrosion (MIC)

The proposed operating conditions are not conducive to microbial growth – the temperature is approximately correct but the pH is either too alkaline or too acid. Further, the system is downstream of the main entry points of microbes.

Conclusion:

MIC is not considered a problem.

h Fatigue/Corrosion Fatigue

Corrosion fatigue is not expected to be a problem.

Conclusions

Not expected to be a concern.

i Vapor Phase Corrosion

The vapor phase portion of the vessel is expected to be contacted with particles of waste from splashing. It is unknown whether this will be sufficiently washed or whether residual acids or solids will be present. Due to the possibility of solid or acids and solids being present, 316L is recommended. In the case of the steam ejector, a high nickel alloy is needed.

Conclusion:

Not expected to be a concern.

j Erosion

Based on past experiments by Smith & Elmore (1992), the solids are soft and erosion is not expected to be a concern for the vessel wall. Based on 24590-WTP-RPT-M-04-0008, a general erosion allowance of 0.016 inch is adequate for components with maximum solids content up to 27.3 wt%. Additional 316L stainless steel should be provided as localized protection for the applicable portions of the bottom head to accommodate PJM discharge velocities of up to 12 m/s with normal maximum solids concentrations of 3.8 wt% and maximum solids concentrations of 27.3 wt% with a usage of 56 % operation as documented in 24590-WTP-MOC-50-00004. UFP-VSL-00001A/B requires at least 0.129-inch additional protection. The 27.3 wt% is considered to be conservative. The fraction of time the solids concentration is expected to be at maximum is 10%. During normal operation, 90 % of the time, the solids content of UFP-VSL-00001A/B is expected to be 3.8 wt%.

The wear of the PJM nozzles can occur from flow for both the discharge and reflood cycles of operation. At least 0.087-inch of additional 316L stainless steel should be provided on the inner surface of the PJM nozzle to accommodate wear due to PJM discharge and suction velocities with solids concentrations of 3.8 wt% and a maximum solids concentration of 27.3 wt% with a usage of 56 % operation as documented in 24590-WTP-MOC-50-00004.

Conclusion:

The recommended corrosion allowance provides sufficient protection for erosion of the vessel wall. Additional localized protection for the bottom head will accommodate PJM discharge velocities and for the PJM nozzles will accommodate PJM discharge and reflood velocities.

k Galling of Moving Surfaces

Not applicable.

Conclusion:

Not applicable.

l Fretting/Wear

No contacting surfaces expected.

Conclusion:

Not applicable.

m Galvanic Corrosion

No significantly dissimilar metals are present.

Conclusion:

Not expected to be a concern.

PLANT ITEM MATERIAL SELECTION DATA SHEET**n Cavitation**

None expected.

Conclusion:

Not believed to be of concern.

o Creep

The temperatures are too low to be a concern.

Conclusion:

Not applicable.

p Inadvertent Nitric Acid Addition

Higher chloride contents and higher temperatures usually require higher alloy materials. Nitrate ions inhibit the pitting and crevice corrosion of stainless alloys. Furthermore, nitric acid passivates these alloys; therefore, lower pH values brought about by increases in the nitric acid content of process fluid will not cause higher corrosion rates for these alloys. The upset condition that was most likely to occur is lowering of the pH of the vessel content by inadvertent addition of 0.5 M nitric acid. Lowering of pH may make a chloride-containing solution more likely to cause pitting of stainless alloys. Increasing the nitric acid content of the process fluid adds more of the pitting-inhibiting nitrate ion to the process fluid. In addition, adding the nitric acid solution to the stream will dilute the chloride content of the process fluid.

Conclusion:

The recommended materials will be able to withstand a plausible inadvertent addition of 0.5 M nitric acid for a limited period.

PLANT ITEM MATERIAL SELECTION DATA SHEET

References:

1. 24590-WTP-MOC-50-00004, Rev. D, *Wear Allowance for WTP Waste Slurry Systems*
2. 24590-WTP-RPT-M-04-0008, Rev. 2, *Evaluation Of Stainless Steel Wear Rates In WTP Waste Streams At Low Velocities*
3. 24590-WTP-RPT-PR-04-0001, Rev. B, *WTP Process Corrosion Data*
4. Danielson, MJ & SG Pitman, 2000, *Corrosion Test of 316L and Hastelloy C-22 in Simulated Tank Waste Solutions*, PNWD-3015 (BNFL-RPT-019, Rev 0), Pacific Northwest Laboratory, Richland WA.
5. Davis, JR (Ed), 1987, *Corrosion, Vol 13*, In "Metals Handbook", ASM International, Metals Park, OH 44073
6. Davis, JR (Ed), 1994, *Stainless Steels*, In ASM Metals Handbook, ASM International, Metals Park, OH 44073
7. Dillon, CP (Nickel Development Institute), Personal Communication to J R Divine (ChemMet, Ltd., PC), 3 Feb 2000.
8. Divine, JR, 1986, Letter to A.J. Diliberto, *Reports of Experimentation*, Battelle, Pacific Northwest Laboratories, Richland, WA 99352
9. Hammer, NE, 1981, *Corrosion Data Survey*, Metals Section, 5th Ed, NACE International, Houston, TX 77218
10. Koch, GH, 1995, *Localized Corrosion in Halides Other Than Chlorides*, MTI Pub No. 41, Materials Technology Institute of the Chemical Process Industries, Inc, St Louis, MO 63141
11. Ohl, PC & WC Carlos, 1994, *Hanford High-Level Evaporator/Crystallizer Corrosion Evaluation*, Presented at Corrosion 94, NACE International, Houston TX 77218.
12. Sedriks, AJ, 1996, *Corrosion of Stainless Steels*, John Wiley & Sons, Inc., New York, NY 10158
13. Smith, H. D. and M. R. Elmore, 1992, Corrosion Studies of Carbon Steel under Impinging Jets of Simulated Slurries of Neutralized Current Acid Waste (NCAW) and Neutralized Cladding Removal Waste (NCRW), PNL-7816, Pacific Northwest Laboratory, Richland, Washington.
14. Zapp, PE, 1998, *Preliminary Assessment of Evaporator Materials of Construction*, BNF-003-98-0029, Rev 0, Westinghouse Savannah River Co., Inc for BNFL Inc.

Bibliography:

1. Jenkins, CF, 1998, *Performance of Evaporators in High Level Radioactive Chemical Waste Service*, Presented at Corrosion 98, NACE International, Houston TX 77084
2. Jenkins, CF. SRTC, teleconference with JR Divine, RPP-WTP, 16 February, 2000.
3. Revie, WW, 2000. *Uhlig's Corrosion Handbook*, 2nd Edition, Wiley-Interscience, New York, NY 10158
4. Uhlig, HH, 1948, *Corrosion Handbook*, John Wiley & Sons, New York, NY 10158
5. Wilding, MW and BE Paige, 1976, *Survey on Corrosion of Metals and Alloys in Solutions Containing Nitric Acid*, ICP-1107, Idaho National Engineering Laboratory, Idaho Falls, ID

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24590-WTP-RPT-PR-04-0001, Rev. B
WTP Process Corrosion Data

PROCESS CORROSION DATA SHEET

Component(s) (Name/ID #) Ultrafiltration feed preparation vessel (UFP-VSL-00001A/B)Facility PTFIn Black Cell? Yes

Chemicals	Unit ¹	Contract Maximum		Non-Routine		Notes
		Leach	No leach	Leach	No Leach	
Aluminum	g/l	7.25E+01	6.91E+01			
Chloride	g/l	2.65E+01	2.93E+01			
Fluoride	g/l	3.14E+01	3.49E+01			
Iron	g/l	5.88E+01	5.98E+01			
Nitrate	g/l	4.96E+02	5.34E+02			
Nitrite	g/l	1.44E+02	1.60E+02			
Phosphate	g/l	1.06E+02	1.15E+02			
Sulfate	g/l	5.56E+01	6.17E+01			
Mercury	g/l	5.66E-01	3.53E-01			
Carbonate	g/l	1.92E+02	2.01E+02			
Undissolved solids	wt%	27.0%	27.3%			Note 3
Other (NaMnO ₄ , Pb,...)	g/l					
Other	g/l					
pH	N/A					Note 4
Temperature	°F					Note 2

List of Organic Species:

References

System Description: 24590-PTF-3YD-UFP-00001, Rev 0
 Mass Balance Document: 24590-WTP-M4C-V11T-00005, Rev A
 Normal Input Stream #: FEP03, HLP12
 Off Normal Input Stream # (e.g., overflow from other vessels): N/A
 P&ID: 24590-PTF-M6-UFP-P0001, Rev 1
 PFD: 24590-PTF-M5-V17T-P0009, Rev 0
 Technical Reports: N/A

Notes:

- Concentrations less than 1×10^{-4} g/l do not need to be reported; list values to two significant digits max
- T normal operation 77 °F to 122 °F for Envelope A, B, C, 68 °F to 86 °F for plant wash (24590-PTF-MVC-UFP-00001, Rev 0)
- Based on HLP12. Other streams entering the vessel will dilute this stream.
- Mainly alkaline streams with a pH range of approximately 12 to 14.

Assumptions:

PLANT ITEM MATERIAL SELECTION DATA SHEET**24590-WTP-RPT-PR-04-0001, Rev. B**
WTP Process Corrosion Data**4.14.2 Ultrafiltration Feed Preparation Vessel (UFP-VSL-00001A/B)****Routine Operations**

Envelope C processing includes solids removal and Sr/TRU precipitation. Therefore, this process is operated separately from the other envelopes (i.e., Envelopes A/D, B/D). Feed during Envelope C processing is received at a target molarity of 6 M sodium. If the feed is received too dilute, the feed may be recycled to the waste feed evaporator feed vessels (FEP-VSL-00017A/B) for further evaporation. Furthermore, if dilution of the feed to 6 M sodium is required, process condensate can be added. Once the vessel level reaches the desired low-level set point for agitation, the pulse jet mixers are activated. The pulse jet mixers run continually until the vessel is emptied below the low level set point.

The precipitation reaction requires a heated solution of 122 °F; therefore, a heating steam ejector is available in the ultrafiltration feed preparation vessel to maintain the necessary reaction temperature. Reagents are added to Envelope C contents in vessels UFP-VSL-00001A or B to commence precipitation. The final concentration of free hydroxide, strontium, and permanganate solutions are 1.0 M OH⁻, 0.075 M Sr²⁺, and 0.05 M MnO₄⁻, respectively. The addition also assumes that the initial concentrations are zero in each case. Therefore, the volume of each reagent added is strictly based on the initial liquid level (volume) in the vessel at the beginning of the reaction.

To perform an effective precipitation strike, the reagents are added in the following order. Initially, 19 M NaOH is added, followed by a sufficient amount of 1.0 M Sr(NO₃)₂ solution. The resulting solution provides the conditions to precipitate out strontium as SrCO₃. Finally, enough 1M NaMNO₄ is added to mathematically achieve a 0.05 M MNO₄ solution. The TRU components precipitate out in the flocculant. After digestion, the solution is diluted from 6 M to 5 M sodium and to cooled back down to 77 °F through the operation of the chilled water cooling jacket. The cooling and dilution sequences can occur at the same time.

Non-Routine Operations that Could Affect Corrosion/Erosion

None identified.